

Dec. 23, 1958

B. J. ZUBRZYCKI ET AL

2,865,504

SEPARATING APPARATUS

Filed Aug. 9, 1956

3 Sheets-Sheet 1

FIG. 1

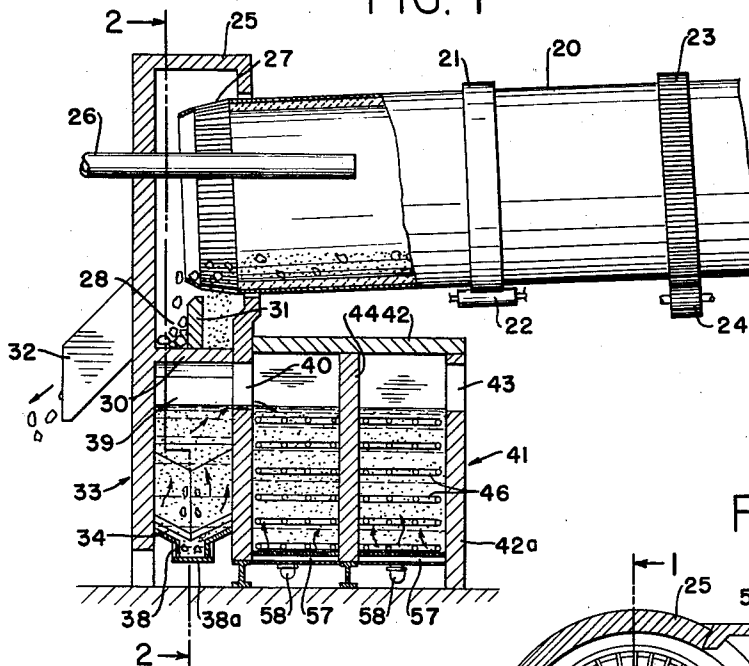


FIG. 2

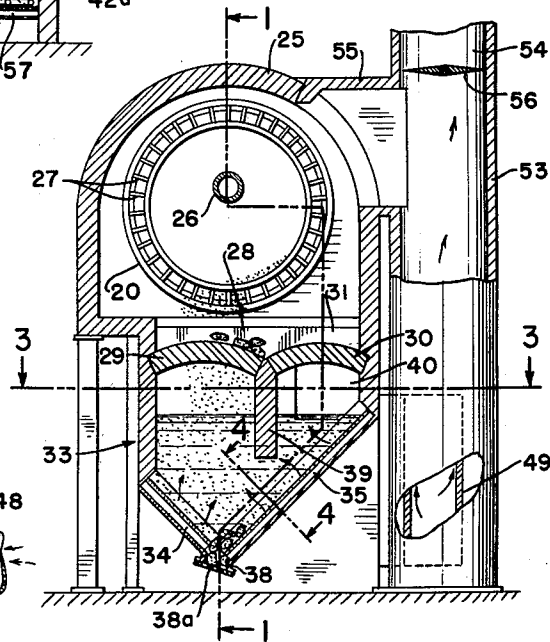


FIG. 4

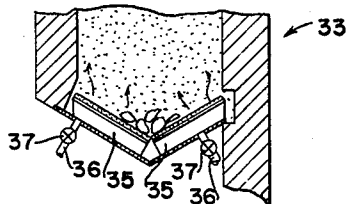
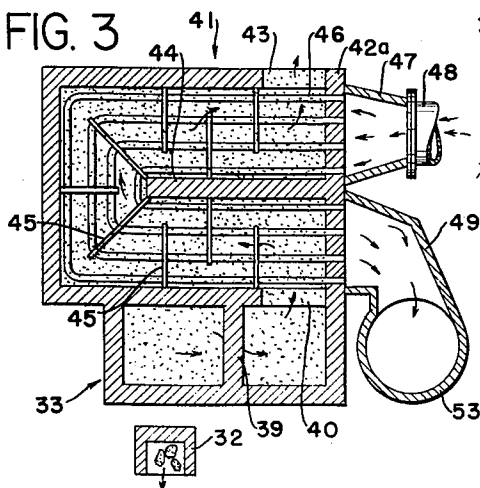


FIG. 3



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FIG. 5

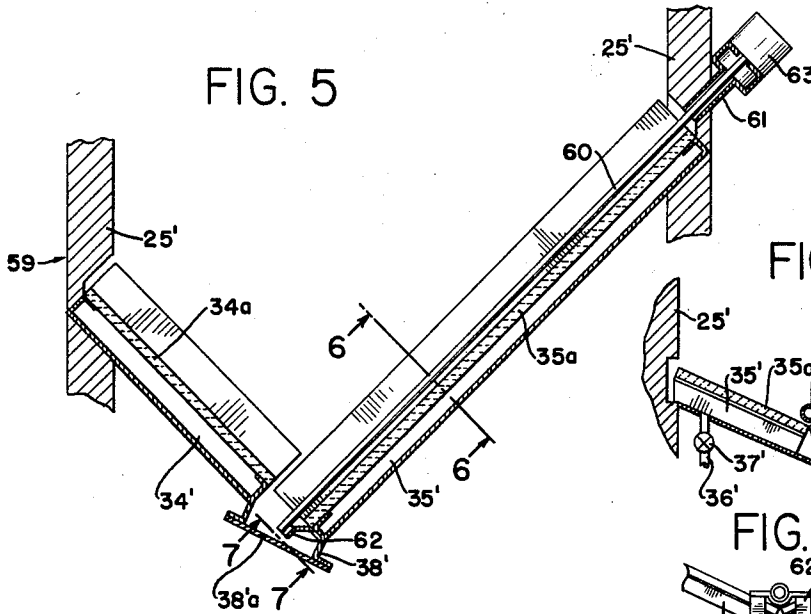


FIG. 6

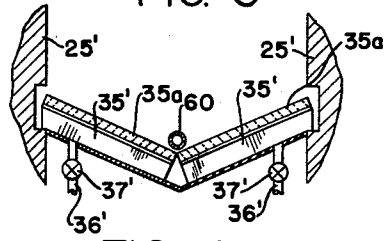


FIG. 7



FIG. 8

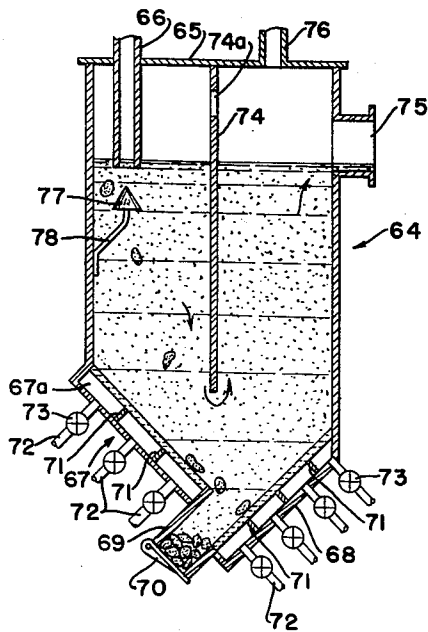
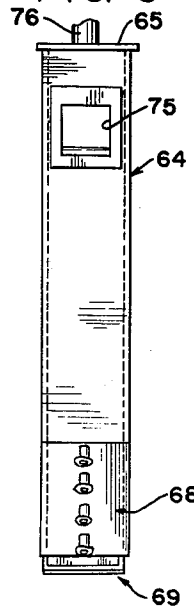


FIG. 9



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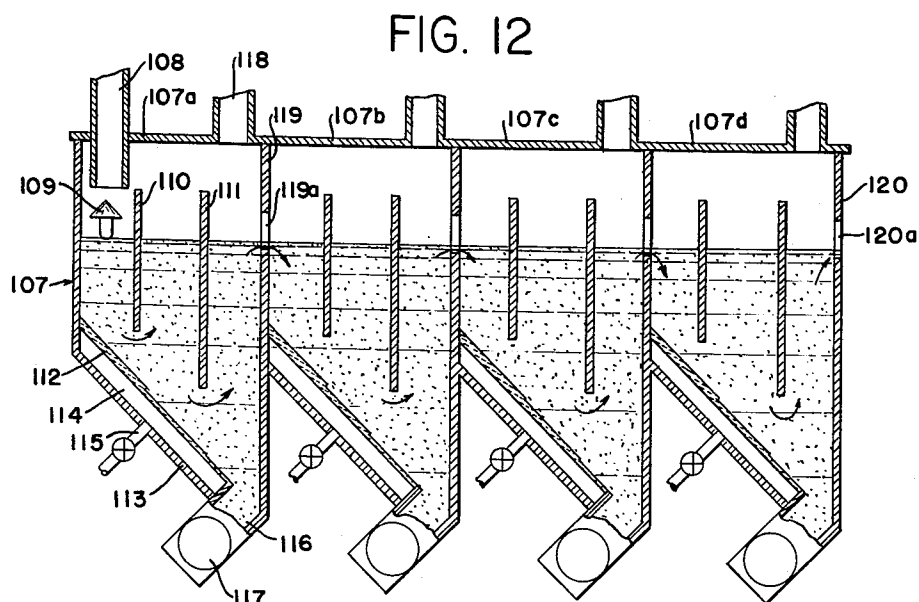
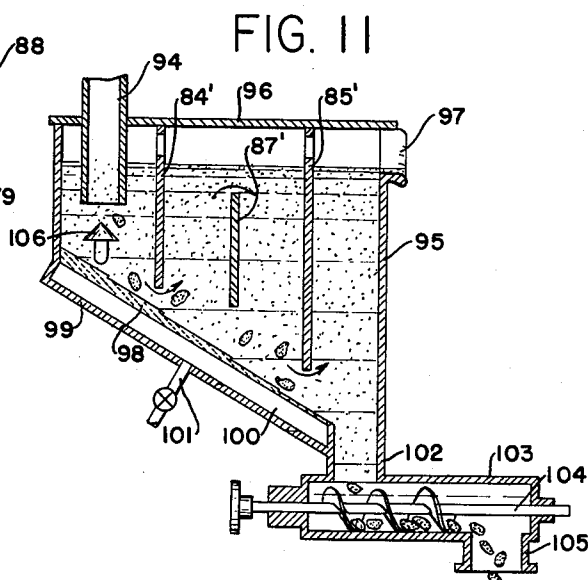
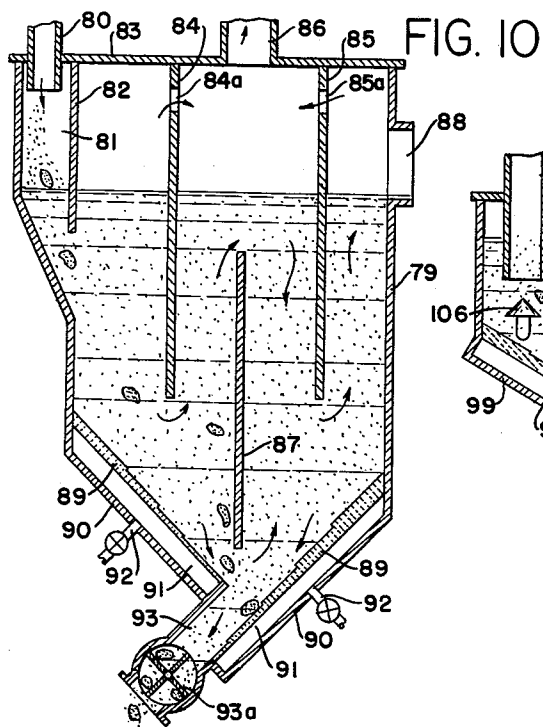
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3 Sheets-Sheet 3



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SEPARATING APPARATUS

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3 Claims. (Cl. 209—138)

This invention relates to the removal of undesired oversize components from a mixture of the components and a finely divided material made up of particles or granules. More particularly, the invention is concerned with a novel method for the separation of the oversize components and a fine material, which can be carried on as a continuous operation and at little expense, and with apparatus, by which the method can be successfully practiced. The method and apparatus of the invention may be employed in connection with various manufacturing operations and offer special advantages, when used in the treatment of hot material discharged from a kiln and to be cooled in a cooler of the fluid-bed type. An example of such a hot material is calcined aluminum oxide, and the application of the method and apparatus to the treatment of that product will be illustrated and described in detail for purposes of explanation.

The manufacture of aluminum oxide is ordinarily carried on by calcining the raw material in a rotary kiln and, as a result of the burning operation, the product discharged from the kiln is made up of fine particles of the oxide but may also contain oversize components, such as lumps or aggregates and pieces of the kiln lining. The fineness of the oxide particles is such that it is desirable to cool the burned material in a fluid-bed cooler, in which the hot material is rendered fluent by aeration and flows through the cooler in indirect heat exchange relationship with the cooling medium traveling through pipes or channels. In such a cooler, the air for aeration is introduced at or near the bottom of the passages for the material at such a rate that the fine oxide particles are held in suspension in the flowing stream of material. The oversize components, however, settle on the bottom of the passages, so that they interfere with the aeration of the material and impair the efficiency of the cooling action, and, if the deposited components are not removed periodically from the cooler, the apparatus may become clogged.

The method of the invention makes it possible to remove oversize components from finely divided materials, which are to be advanced, as through a cooler, by being aerated to fluent condition and, in the practice of the method, the mixture of the components and materials is caused to flow first downward and then upward along a path bounded adjacent the point of reversal of flow by a porous wall, through which air is introduced into the mixture to fluidize it. The rate of supply of the air is controlled, so that the velocity of the air decreases in a direction down the wall, but is low enough near the upper end of the wall to permit the foreign substances and lumps to sink and sufficiently high near the lower end of the wall to maintain the particles fluidized. Adjacent the lower end of the wall, there is an outlet for the oversize components and they are regularly removed, so that they cannot interfere with the aeration of the material flowing along the path.

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In its simplest form, the apparatus for the practice of the method includes a separating chamber having at least one partition extending downward from the top toward the chamber bottom, which is made of at least one inclined porous wall, through which air for aeration is introduced. The chamber has an inlet and an outlet for material at opposite sides of the partition and an outlet near the lower end of the inclined wall, through which the deposited oversize components can be removed. When the apparatus is to be used in handling aluminum oxide discharged from a rotary kiln and to be passed to a fluid-bed cooler, the separating chamber may be built in the bottom of the kiln hood, so that the material issuing from the kiln falls into the chamber at one side of the partition. The material outlet at the other side of the partition may then lead directly into one end of the material passage through the fluid-bed cooler.

For a better understanding of the invention, reference may be made to the accompanying drawings, in which

Fig. 1 is a view, partly in vertical section on the line 1—1 of Fig. 2 and partly in elevation, of a rotary kiln installation, in which a separating apparatus embodying the invention is employed between the kiln and a fluid-bed cooler;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1; Figs. 3 and 4 are sectional views on the lines 3—3 and 4—4, respectively, of Fig. 2;

Fig. 5 is a vertical sectional view of a modified form of the separating apparatus shown in Fig. 2;

Figs. 6 and 7 are sectional views on the lines 6—6 and 7—7, respectively, of Fig. 5;

Fig. 8 is a vertical sectional view of another form of the separating apparatus;

Fig. 9 is an end elevation of the apparatus of Fig. 8; and

Figs. 10, 11, and 12 are vertical sectional views of three modified forms of the apparatus of Fig. 8.

The rotary kiln installation illustrated in Figs. 1 to 4, inclusive, is suitable for the production of aluminum oxide and it comprises a rotary kiln 20 supported for rotation with its longitudinal axis at a low angle to the horizontal. For this purpose, the kiln is provided with a number of tires 21 resting upon rollers 22 and it is rotated by means of a gear 23 meshing with one or more driving pinions 24. The discharge end of the kiln lies within a hood 25, through the front wall of which the burner pipe 26 extends to terminate within the kiln. At its lower end, the kiln is provided with a grating 27, through which the greater part of the hot burned material issuing from the kiln may fall, while relatively large lumps pass over the grating and drop into a space 28 within the hood, which is bounded at its bottom by arches 29 and 30, by the front and side walls of the hood, and by a barrier 31, which rises from the arches between the front and rear walls of the hood. The front wall of the hood is formed with an opening leading from the space 28 for discharge of the lumps and an inclined chute 32 leads downward from the opening.

The arch 30 extends without interruption between the front and rear walls of the hood 25, but an opening is formed in arch 29 beneath the grate and between the barrier and the rear wall of the housing. The material falling through the grate, accordingly, drops through the opening and enters a separating chamber 33, which is formed between the walls of hood 25 beneath the arches 29, 30. The separating chamber is closed at the bottom by downwardly convergent pairs of aerating chambers 34, 35 and the chambers of each pair are also downwardly convergent, so that each pair of chambers forms a trough.

The lower wall of each chamber is impervious, while the upper wall is porous, and air is supplied to the chambers through air supply pipes 36 having valves 37. The outer walls of the aerating chambers are formed to provide a central outlet 38 at the bottom of the separating chamber and the outlet is normally closed by a removable door 38a. When air at sufficient pressure is supplied to the chambers 34, 35, the air escapes through their porous inner walls and fluidizes finely divided material in the separating chamber.

A partition 39 extends downward from the junction of arches 29, 30 and terminates a distance above the air chambers 35. As soon as material entering the separating chamber at one side of partition 39 through the opening through arch 29 becomes aerated, the material flows beneath the lower end of the partition and rises on the other side of it. The rising material is free to escape from the aerating chamber through a discharge opening 40 in the rear wall of the hood 25.

The opening 40 leads into a fluid-bed cooler 41, which may be of any conventional type, and the cooler illustrated includes a housing 42, the front wall of which is formed by the rear wall of hood 25. The housing has an outlet in its rear wall in line with the inlet 40 and a partition 44 subdivides the interior of the housing, so that the material traveling from the inlet 40 to the outlet 43 passes along one side of the partition and then returns along the other. The passages for material within the housing at opposite sides of the partition are further subdivided by partitions 45 attached to the housing walls and to partition 44 and arranged to cause the material traveling through the housing on either side of the partition 44 to travel along a tortuous path.

The pulverulent material traveling through the housing 42 is indirectly cooled by a cooling medium and, for this purpose, in the cooler shown, air pipes 46 of U-shape are mounted to lie horizontal and with their ends extending through wall 42a on opposite sides of the partition 44. Air is supplied to the inlet ends of the pipes through an inlet casing 47 connected by a pipe 48 to the outlet of a fan, and the air issuing from pipes 46 enters an outlet casing 49 connected to a riser pipe 53. The pipe 53 is connected to an exhaust stack 54 and to a pipe 55, which leads to an opening through the wall of hood 25. A damper 56 is mounted at the bottom of stack 54 and can be adjusted to determine the relative quantities of the air supplied to the hood to be used as secondary air of combustion in the kiln and allowed to escape up the stack. The bottom of the cooler is formed by aerating chambers 57 having porous upper walls and supplied with air by pipes 58.

In the use of the apparatus shown in Fig. 1 in the production of alumina, any large lumps of burned material issuing from the kiln pass over the grating and, after entering the space 28 in the hood, are discharged through the chute 32, while the material fine enough to pass through the grate enters the separating chamber 33 at one side of the partition 39. This material is made up mainly of finely divided aluminum oxide, which is rendered fluent by the air diffused into the chamber through the porous inner walls of the aerating chambers 34, 35, but the material may also contain pieces of the kiln lining and other foreign substances and lumps. The volume and pressure of the air diffused into the chamber 34, 35 is such that while it will render the alumina fluent, it will not maintain the undesired and less-readily suspendible foreign substances and lumps in suspension. Therefore, such undesired components settle through the fluidized material and enter the outlet 38 at the bottom of chamber 33 above the door 38a, while the fluidized fine material rises in the chamber 33 at the side of partition 39 leading to the opening 40 and enters the cooler 41 through the opening. Within the cooler, the material is maintained fluent by air diffused into the material through the porous top walls of aerating chambers 57 and the material travels

through the casing of the cooler along a tortuous path to pass around the end of partition 44 and return for discharge through opening 43. In its travel through the cooler, the material is cooled by indirect heat exchange with air traveling through pipes 46 and part of the air thus heated is used as secondary air of combustion in the kiln while the remainder is discharged.

In the installation of Fig. 1, the separating chamber makes it possible to eliminate from the finely divided aluminum oxide oversize components, which would fall out of the stream of material traveling through the fluid-bed cooler and be deposited upon the aerating chambers at the bottom thereof. The deposit of such components upon the porous walls of the chambers would soon impair the aerating action and reduce the cooler efficiency and, if the components were not removed regularly, they might cause the cooler to clog. The separating chamber 33 between the kiln and the cooler removes the undesired components from the finely divided aluminum oxide, so that the cooling can proceed without interference.

The essential features of a modified form of separating chamber 59, which may be employed in place of chamber 33, are illustrated in Figs. 5 to 7, inclusive, and the modified chamber is defined laterally by the walls 25' of the kiln hood. The bottom of the separating chamber is formed by pairs of downwardly convergent aerating chambers 34', 35', which are similar to the chambers 34, 35 and include porous inner walls 34a, 35a supplied with air through pipes 36' having valves 37'. The chambers of each pair are convergent and their lower walls are formed to provide an outlet 38' closed by a door 38'a. A rod 60 lies in the trough between the two chambers 35' and it is supported at its upper end in a bushing 61 extending through an opening in the wall 25' of the hood and at its lower end by a bracket 62 attached to the walls of chambers 35'. A suitable vibrating device 63 is attached to the upper end of the rod and the agitation of the rod imparts movement to the heavy substances lying near it, so that they flow downwardly by gravity and do not collect in the trough formed by chambers 35' and prevent the free movement of the coarse material down the surfaces of the chambers to the outlet 38'.

A simple form of the separating apparatus is illustrated in Fig. 8 as comprising a tank 64, which may be oblong in cross-section and is closed at the top by a cover 65, through which an inlet pipe 66 for admission of the material mixture extends. The bottom of the tank is formed by a pair of aerating chambers 67, 68 and the top of chamber 67 lies at a higher level than the top of chamber 68, so that the lower end of chamber 68 may terminate beneath and substantially in alignment with the lower end of chamber 67. At their lower ends, the walls of the chambers are extended to define an outlet compartment 69 normally closed by a swinging door 70. The chambers 67, 68 are subdivided by transverse partitions 71 into compartments, to which air is supplied through separate air pipes 72 having valves 73. A partition 74 extends downwardly from the cover 65 in the transverse median plane of the tank 64 to terminate above the aerating chambers and the partition has an opening 74a through it. The wall of the tank 64 at the side of partition 74 remote from the inlet 66 has a material outlet 75 and an air outlet 76 leads from the top of the tank at the same side of partition 74 as the outlet 75. A deflector 77 mounted on a bracket 78 attached to the wall of the tank lies beneath the lower end of inlet 66.

In the operation of the separating apparatus of Fig. 8 for the separation of undesired components in the form of lumps and foreign bodies from a finely divided material, the material mixture is fed into the tank through the inlet and the finely divided material is fluidized by air, which is diffused through the porous upper walls of the aerating chambers 67, 68. The air rising through the material on opposite sides of partition 74 escapes

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through the air outlet 76 with the air at the inlet side of the partition passing through the opening 74a in the partition on its way to the outlet. The deflector 77 prevents any of the air from escaping upwardly through the material inlet 66. As the finely divided material entering the tank at one side of partition 74 is fluidized, the material rises on the opposite side of the partition and is discharged through the material outlet 75.

In order to effect the separation of the oversize components, the air valves 73 are so adjusted that the air supplied to the highest compartments of the aerating chambers enters the material mixture from those compartments at a velocity slightly less than the minimum value, which would maintain the undesired components in suspension. The valves 73, through which air is supplied to the lowest compartments of the chambers, are so adjusted that the velocity of the air entering the material from those chambers is slightly in excess of the minimum value for maintaining the finely divided material in fluent condition. The air issuing from the intermediate compartments is controlled by the valves, so that its velocity is between the velocities of the air issuing from the highest and lowest compartments. Because of the inclination of the aerating chambers, the head of fluidized material above the topmost compartments of the chambers offers considerably less resistance to air flow than the head above the compartments at the lower ends of the chambers. Because of this and of the adjustment of the air supply to the compartments as described, the velocity of the air entering the material from the chambers varies in a direction down the tops of the chambers fairly uniformly from slightly below the minimum value, which would prevent the undesired components from sinking through the fluidized material to slightly above the minimum value required for maintaining the fine material fluent. The undesired components, accordingly, sink slowly through the fluidized material and enter the outlet 67, from which they can be periodically removed by opening the door 70.

In the modified form of the separating apparatus shown in Fig. 10, the tank 79 has a material inlet 80 leading into a laterally offset compartment 81 defined in part by a partition 82, which extends downwardly from the top 83 of the tank and terminates below the normal level of the material in the tank. The partition leaves the bottom of compartment 81 open to the interior of the tank, so that the material entering the compartment may pass through it and into the tank. In addition to partition 82, the tank includes partitions 84, 85 extending downward from the top of the tank and having air openings 84a, 85a, respectively, near their upper ends. An air outlet 86 leads from the top of the tank between partitions 84, 85 and a partition 87 is mounted between partitions 84, 85 and lies wholly submerged in the material within the tank during operation. A material outlet 88 is provided in the wall of the tank remote from the chamber 81.

At its bottom, the tank is provided with inner porous walls 89, which are convergent downwardly and lie at different heights. Outwardly from each of the porous walls, the tank has a solid wall 90 and the solid and porous walls of each pair form an air chamber 91, to which air is supplied through pipes 92. At the lower ends of the chambers, the walls 90 are extended to form an outlet 93 containing a rotary gate valve 93a.

The air chambers 91 are not divided into compartments, as in the construction of Fig. 8, but the desired variation in the velocity of the air entering the material is obtained by varying the resistance to the flow of air through the porous walls. For this purpose, the walls may be made, as shown, in transverse sections decreasing in thickness in a direction down the walls. The thickest sections of the walls at the upper ends of the air chambers do not wholly correct for the resistance to flow offered by the reduced head of material above these sections and slightly more air is likely to pass through the

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thickest sections of the porous walls at the upper ends thereof than through the thinner sections farther down the walls. However, the thickness of the walls and the pressure of the air supplied to the air chambers are such that the air entering the material through the top sections of the walls has a velocity slightly less than the minimum value which would maintain the undesired components in suspension. The velocity of the air entering the material decreases in a direction down the walls and the velocity of the air entering the material through the thinnest sections of the walls is above the minimum value required for maintaining the fine material fluent. Instead of forming the porous walls 89 with sections of different thickness, the desired result may be obtained by making the walls of ceramic material of uniform thickness but varying in porosity.

In the operation of the apparatus shown in Fig. 10, the material mixture entering the tank through inlet 80 falls upon the porous wall 89 below the inlet and the finely divided constituent is fluidized, while the undesired components settle through the fluidized material. As the operation proceeds, the tank becomes filled with fluidized material, which travels beneath partition 84, above and below partition 87, and beneath partition 85 on the way to the material outlet 88. The undesired components sink through the fluidized material and enter the outlet 93, from which they are discharged through the valve 93a, while the air escapes through the air outlet 86.

The form of separating apparatus shown in Fig. 11 is closely similar to that shown in Fig. 10, except that the material inlet 94 extends directly into the tank 95 through its top 96 and terminates below the level of the material outlet 97. The tank contains partitions 84', 85', and 87' similar in construction and function to the partitions 84, 85, and 87, respectively, of the Fig. 10 construction. The tank 95 has a single porous wall 98, which is inclined downwardly and, with an outer solid wall 99, forms an air chamber 100 supplied with air through a pipe 101. The air chamber 100 terminates close to the wall of the tank containing outlet 97 and, at the lower end of the air chamber, there is an outlet 102 from the tank leading to a screw conveyor 103 containing a shaft 104 and having an outlet 105. In the operation of the apparatus, the shaft is preferably driven continuously at a slow rate. The wall 98 of air chamber 100 is of decreasing thickness or of increasing porosity in a direction down the wall in order to vary the velocity of the air entering the material for the purposes previously explained. In order to prevent escape of air through inlet 94, a deflector 106 is mounted within the tank below the inlet.

The apparatus shown in Fig. 12 is made up of four identical tanks 107 disposed in a row. The first tank 107a has an inlet 108 for material and contains an air deflector 109 below the lower end of the inlet. A pair of partitions 110, 111 are mounted below the top of the tank and terminate within the material at a distance above the inner porous inclined bottom wall 112 of the tank. The tank has an outer impervious wall 113, which cooperates with wall 112 to form an air chamber 114 supplied with air through a pipe 115. The wall 112 is of decreasing thickness or of increasing porosity in a direction down the wall. At the lower end of the wall, the tank is provided with an outlet 116 containing a rotary gate valve 117, and the tank has an air outlet 118 above the outlet 116. The wall 119, which is common to tank 107a and tank 107b next to it, has an opening 119a for passage of material. Tank 107b and the remaining tanks 107c and 107d are similar to tank 107a and the fluidized material issues from tank 107d through an opening 120a in the end wall 120 of the tank.

In order to show the effectiveness of the separation produced by the use of the invention, the results obtained by means of the apparatus shown in Fig. 8 but with inclined walls of varying thickness, as shown in Fig. 10,

are given. The material mixture supplied to the apparatus contained 10,000 parts by weight of aluminum oxide and 400 parts of crushed brick. The particle size of the aluminum oxide was such that 99.5% could pass through a screen with openings of 0.037 mm., while all the brick pieces could pass through a screen with a mesh width of 4.76 mm. but were retained on a screen with a mesh width of 2 mm. The material was treated in the apparatus in the usual way and screen analyses were made of the material, which passed through the apparatus, and of the material, which collected at the bottom of the tank. It was found that 10 kg. of the material, which passed through the apparatus, contained only 2.5 g. of material unable to pass a screen with a mesh width of 2 mm. and the remaining coarse material collected in the material outlet. The apparatus thus removed approximately 99.4% of the undesired components in the mixture having a particle size greater than 2 mm. Such a separation is regarded as highly satisfactory.

We claim:

1. An apparatus for separating undesired components in the form of foreign substances and lumps from a mixture of the components and a finely divided material, which comprises a chamber having a bottom including an air-permeable section inclined upwardly toward a wall of the chamber, the chamber having an inlet and an outlet for solids at a distance above the bottom, an outlet for the components adjacent the lower end of the inclined bottom section, means for introducing air through the inclined bottom section to aerate the mixture within the chamber, vertical partition means within the chamber above its bottom, and means for agitating the contents of the chamber extending along said inclined section and reciprocable lengthwise.

2. A method of separating undesirable components in the form of less-readily suspendible foreign substances and lumps from a mixture of such components and a

finely-divided, more readily suspendible material which comprises introducing the mixture into an upper portion of a space at one side thereof, causing the entire mixture to flow downwardly at said side of the space in a confined zone which terminates a distance above the bottom of said space, introducing gas into said space at a level below the bottom of said confined zone and over an area extending to the side of said space opposite that into which the mixture was introduced, the gas being introduced in such volume and at such pressure as to render fluent the finely-divided, more-readily suspendible material, but in volume and at pressure insufficient to maintain the undesired and less-readily suspendible foreign substances and lumps in suspension, whereby such undesirable foreign substances and lumps are separated from the finely-divided, more-readily suspendible material and settle to the bottom of said space, while the finely-divided more-readily suspendible material flowing from the bottom of said confined zone rises through said opposite side of the space, and discharging said finely-divided, more-readily suspendible material from an upper portion of said opposite side of the space.

3. The method of claim 2 which further includes subjecting to mechanical agitation undesired and less-readily suspendible foreign substances and lumps separated from the more-readily suspendible material.

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